Distributed Energy Road Show
Austin, Texas

as presented by

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Burns & McDonnell

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Agenda

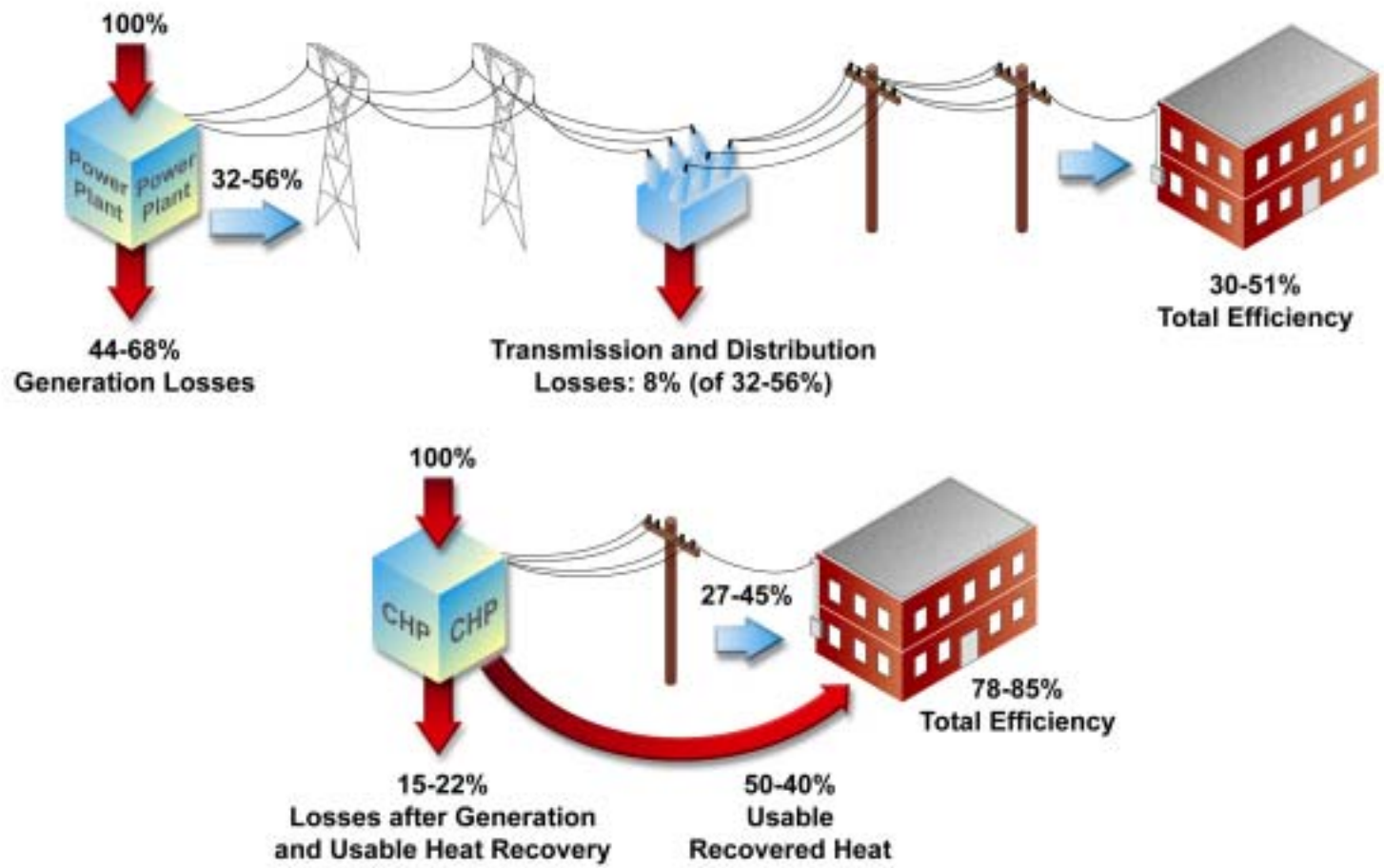
- **CHP Overview**
- **CHP Technology Overview**
- **DOE Solicitation Overview**
- **BCHP Project Team Approach**

CHP Overview

What is CHP?

- Integrated System
- Located At or Near a Building/Facility
- Provides a Portion of the Electrical Load
- **Utilizes the Waste Heat to Generate Useful Thermal Energy**
  - Cooling
  - Heating
  - Dehumidification
  - Process Heat

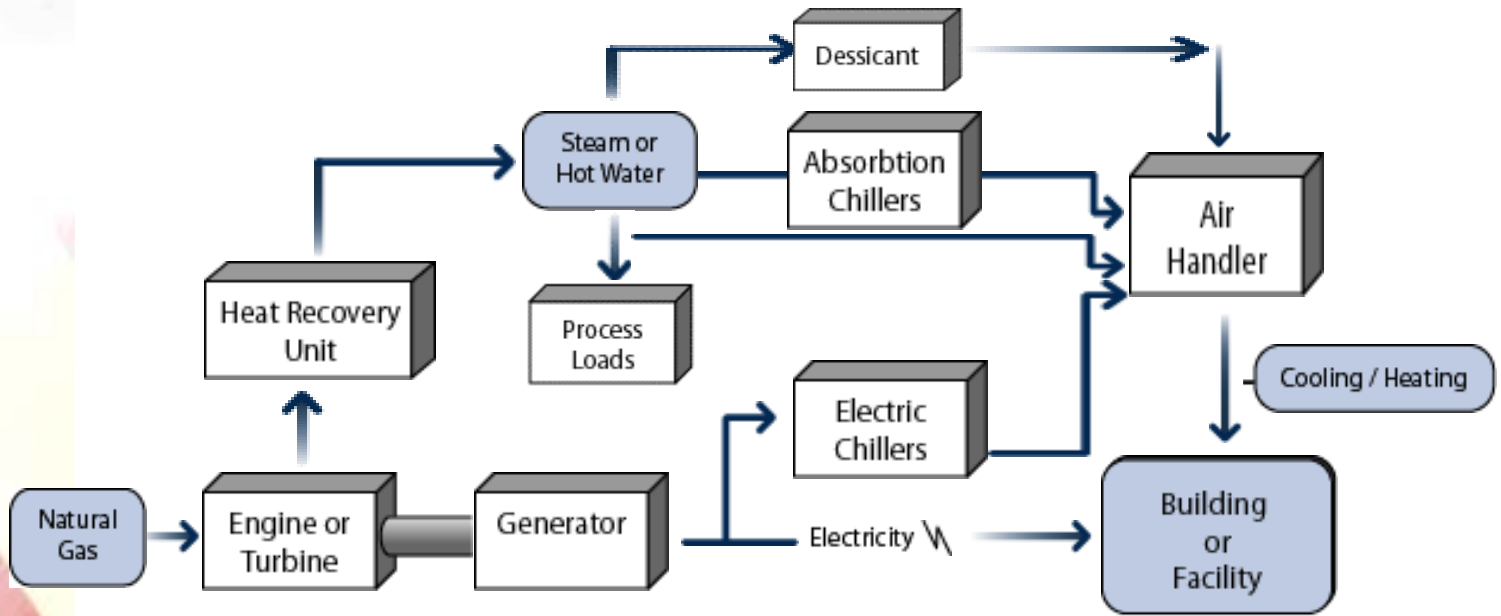
CHP Improves Efficiency



CHP System Sizes *(Terminology)*

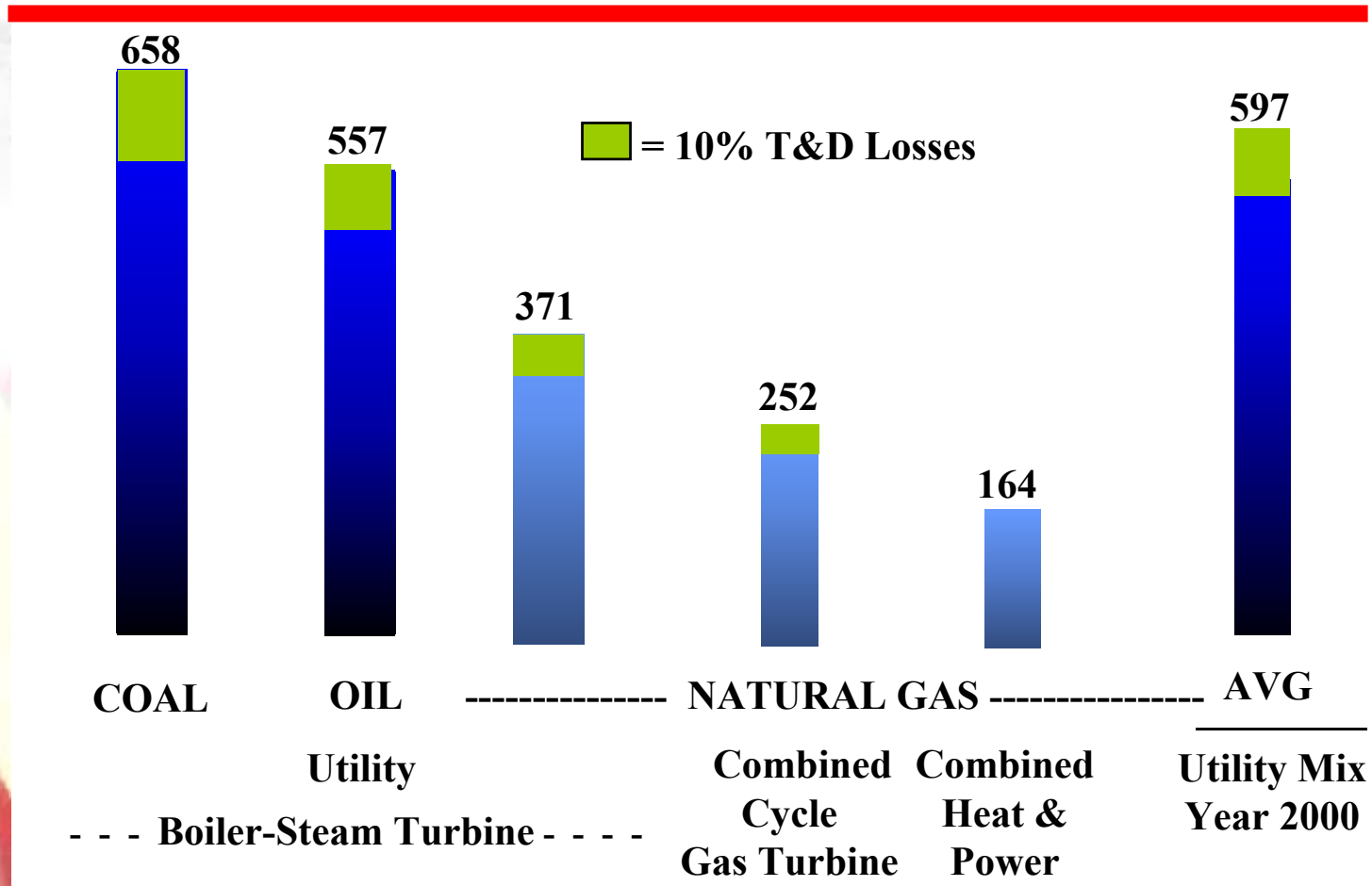
System Designation	Size Range	Comments
Mega	50 to 100+ MWe	• Very Large Industrial • Usually Multiple Smaller Units • Custom Engineered Systems
Large	10's of MWe	• Industrial & Large Commercial • Usually Multiple Smaller Units • Custom Engineered Systems
Mid	10's of kWe to Several MWe	• Commercial & Light Industrial • Single to Multiple Units • Potential Packaged Units
Micro	<60 kWe	• Small Commercial & Residential • Appliance Like

Typical Commercial CHP System

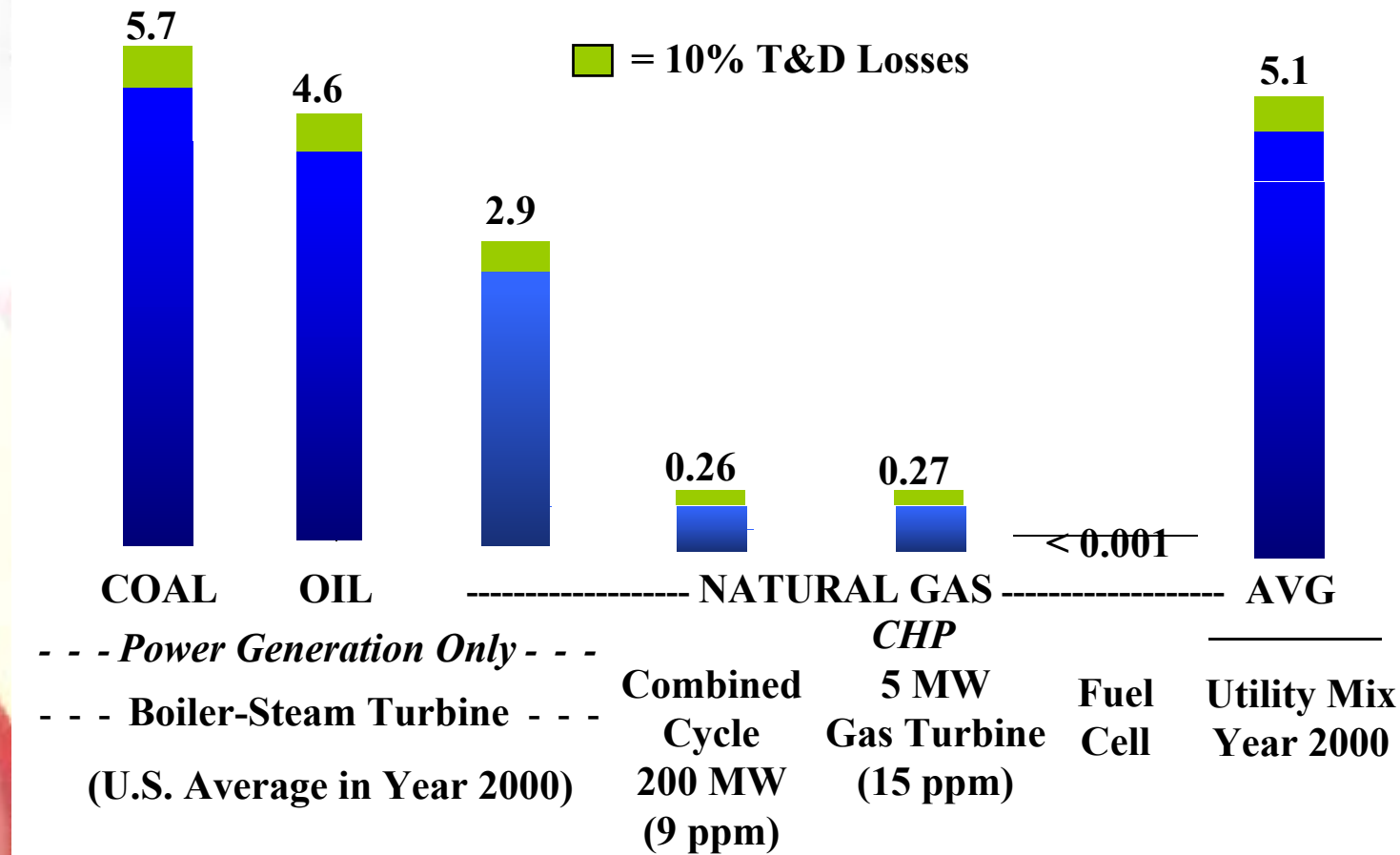


Global Warming Implications of CHP

(lb/MWh of Carbon Equivalent)



NO_X Implications of CHP
(lb/MWh of NO_X)



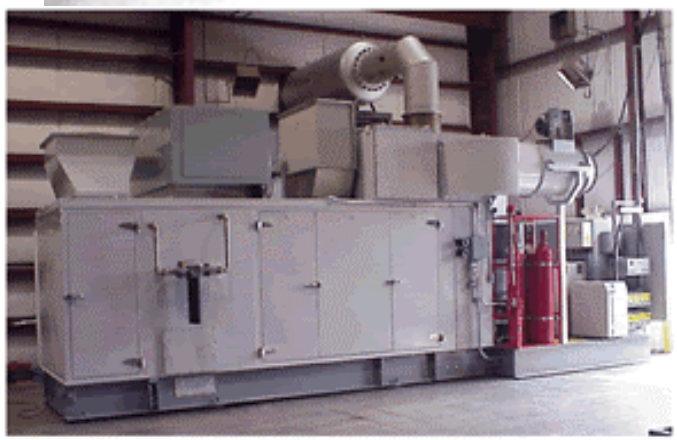
Benefits of CHP

High Efficiency, On-Site Generation Means …

- Improved Reliability
- Lower Energy Costs
- Better Power Quality
- Provides Standby Power
- Lower Emissions (including CO2)
- Support Grid Infrastructure
  - Fewer T&D Constraints
  - Defer Costly Grid Upgrades
  - Price Stability
- Facilitates Deployment of New Clean Energy Technologies
- Enhances Competition

CHP Technology Overview

Gas Combustion Turbines



- Available Size Range: 500 kW - Hundreds of MW
- Efficiency Range: 25% to 40% LHV (Simple Cycle)
- Typically 3 Configurations:
  - Simple Cycle (Most Common in CHP)
  - Recuperated
  - Combined Cycle
- Thermal (Recoverable) Energy:
  - Exhaust Gas @ 900 °F to 1100 °F
  - Excellent for High Grade Steam @ 150 psig and Higher

Reciprocating Engines

- Fastest Selling, Least Expensive CHP Prime Mover Technology Below 5 MW
- Typical Power Range: 5 kW - 10 MW
- Efficiency Range: ≈ 25% - 40% LHV
- Part Load Operation: OK
- Type of Engines:
  - Spark Ignited --- Natural Gas/ Gasoline/ Biogas
  - Compression Ignition --- Diesel
  - Dual Fuel –Diesel Pilot

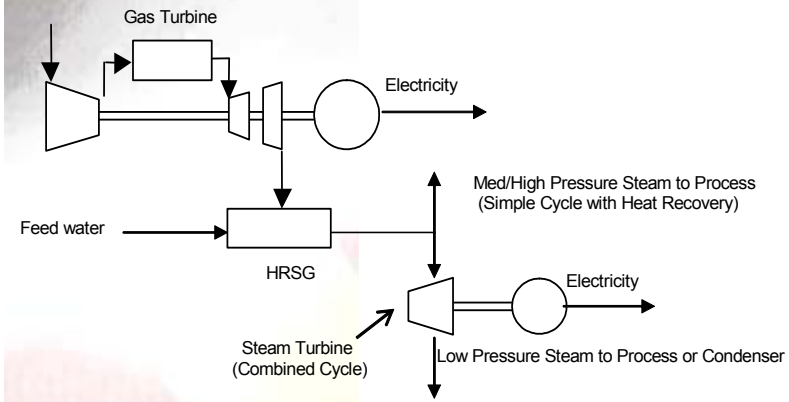
Microturbines

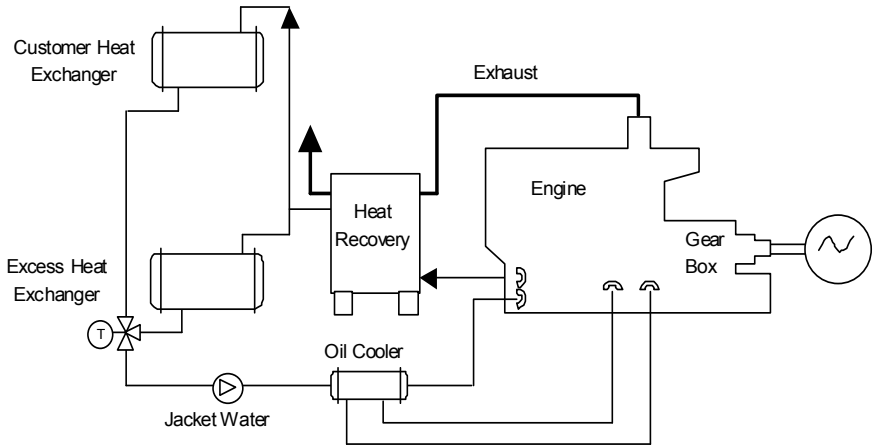
- Small Turbines with Recuperation
- Capacity Range: 25 kW to 400 kW
- Efficiency Range: 25% to 30% LHV
- Recoverable Heat: Gas Exhaust @ Approximately 500 °F

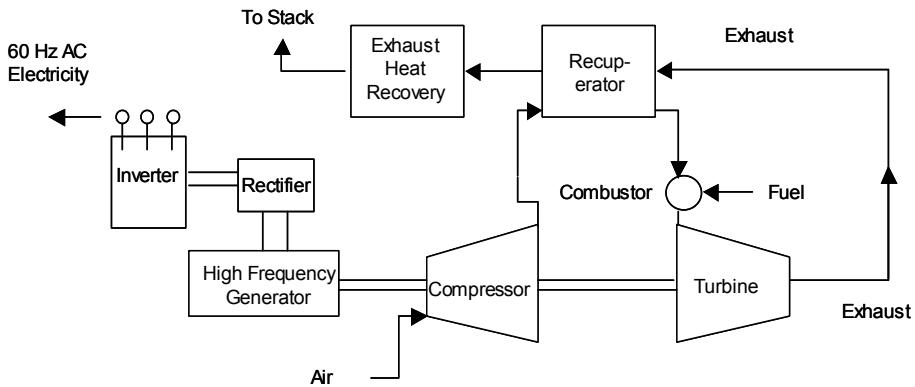
Fuel Cells

Fuel Cell Type	Availability	Efficiency	Operating Temperature	Heat Utilization
Phosphoric Acid (PAFC)	Commercial >$3,500/kW	38 – 45%	480 °F	Hot Water
Solid Oxide (SOFC)	Demonstration	40 – 45%	1,800 °F	High Pressure Steam
Molten Carbonate (MCFC)	Demonstration	50 – 60%	1,200 °F	Medium to High Pressure Steam
Proton Exchange Membrane (PEM)	Demonstration	33 –45%	175°F	Hot Water

CHP Configurations

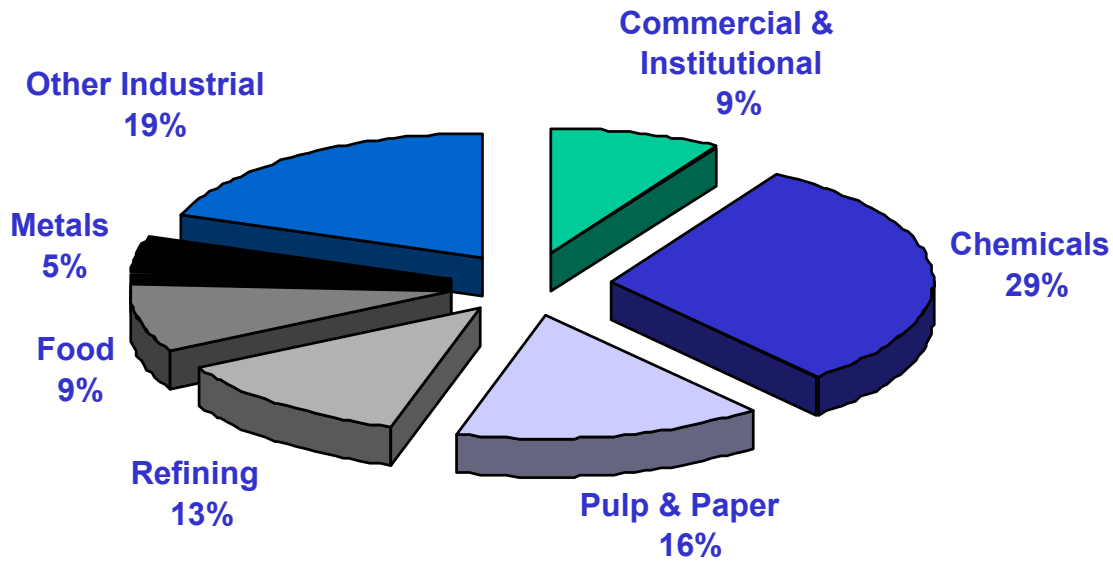






CHP Market Overview

U.S. CHP Capacity
52,800 MW (1999)

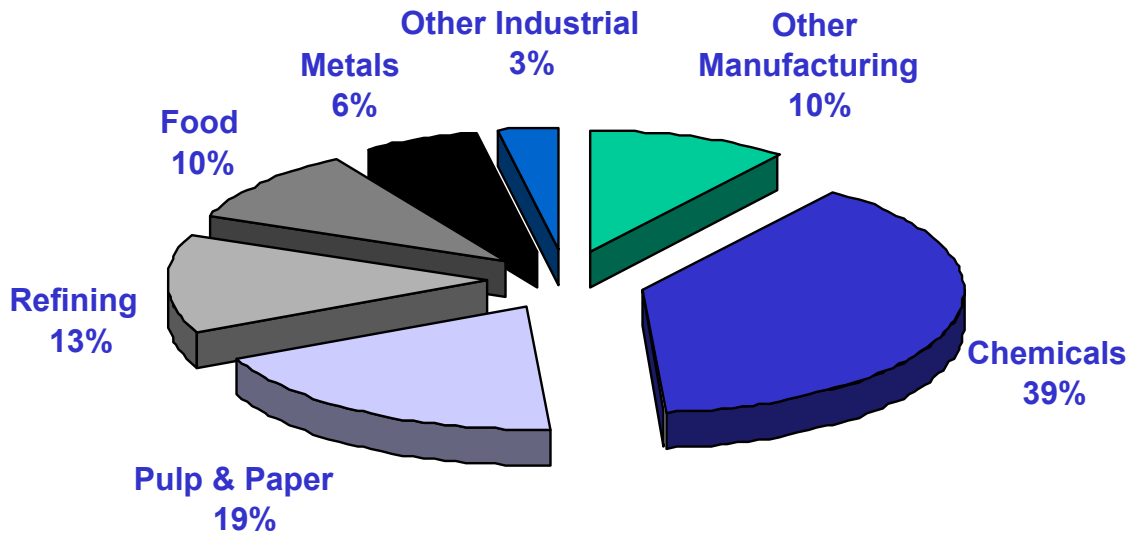


National CHP Roadmap

U.S Department of Energy

Environmental Protection Agency

U.S. Industrial CHP Capacity 45,500 MW (1999)

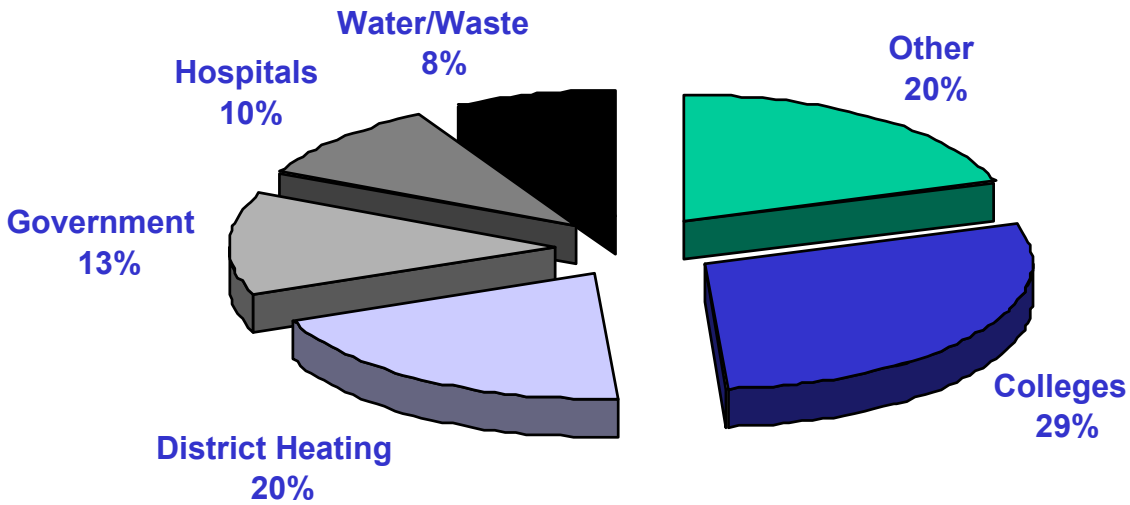


National CHP Roadmap

U.S Department of Energy

Environmental Protection Agency

U.S. Commercial CHP Capacity 4,930 MW (1999)



National CHP Roadmap

U.S Department of Energy

Environmental Protection Agency

Where is CHP going?

- 8 to 10 Year Window of Opportunity
  - 500 kW - 20 MW Range
- DOE is Pushing CHP Technologies Very Hard Right Now **(CHP Roadmap 46 GW by 2010)**
- Combining Projects With FEMP
- United States Combined Heat & Power Association

CHP Markets and Technologies

- Targeted CHP Markets and Goals
  - Industrial plants - manufacturing and processing **(27 GW)**
  - Buildings - commercial, individual schools and hospitals and multi-family **(8 GW)**
  - District energy systems - college campuses, hospital complexes, commercial campuses, airports and communities/municipalities **(8 GW)**
  - Federal facilities - buildings and manufacturing plants **(5 GW)**

CHP Markets and Technologies

- Primary CHP Technologies
  - Gas turbines **(over 60 % of the market)**
  - Steam cycle boilers **(over 30 % of the market)**
  - Natural gas engines **(under 5% of the market)**

Industrial CHP Potential

- Potential for 75 to 100 GW of additional CHP in manufacturing industries
- CHP could save users $9 billion/year in energy costs and prevent the release of almost 65 million metric tons of carbon equivalent
- 25% of potential is in size range of reciprocating engines and microturbines
- Additional potential in non-steam CHP and mechanical drive

Commercial/Institutional Market

- Significant potential exists
- Market penetration to-date is extremely low
- Majority of existing capacity is in larger systems (>20 MW)
- Majority of technical potential is in smaller sizes (< 1 MW)
- Application of advanced technologies that use thermal energy will expand market potential
  - Heat-activated cooling
  - Thermally regenerated desiccant

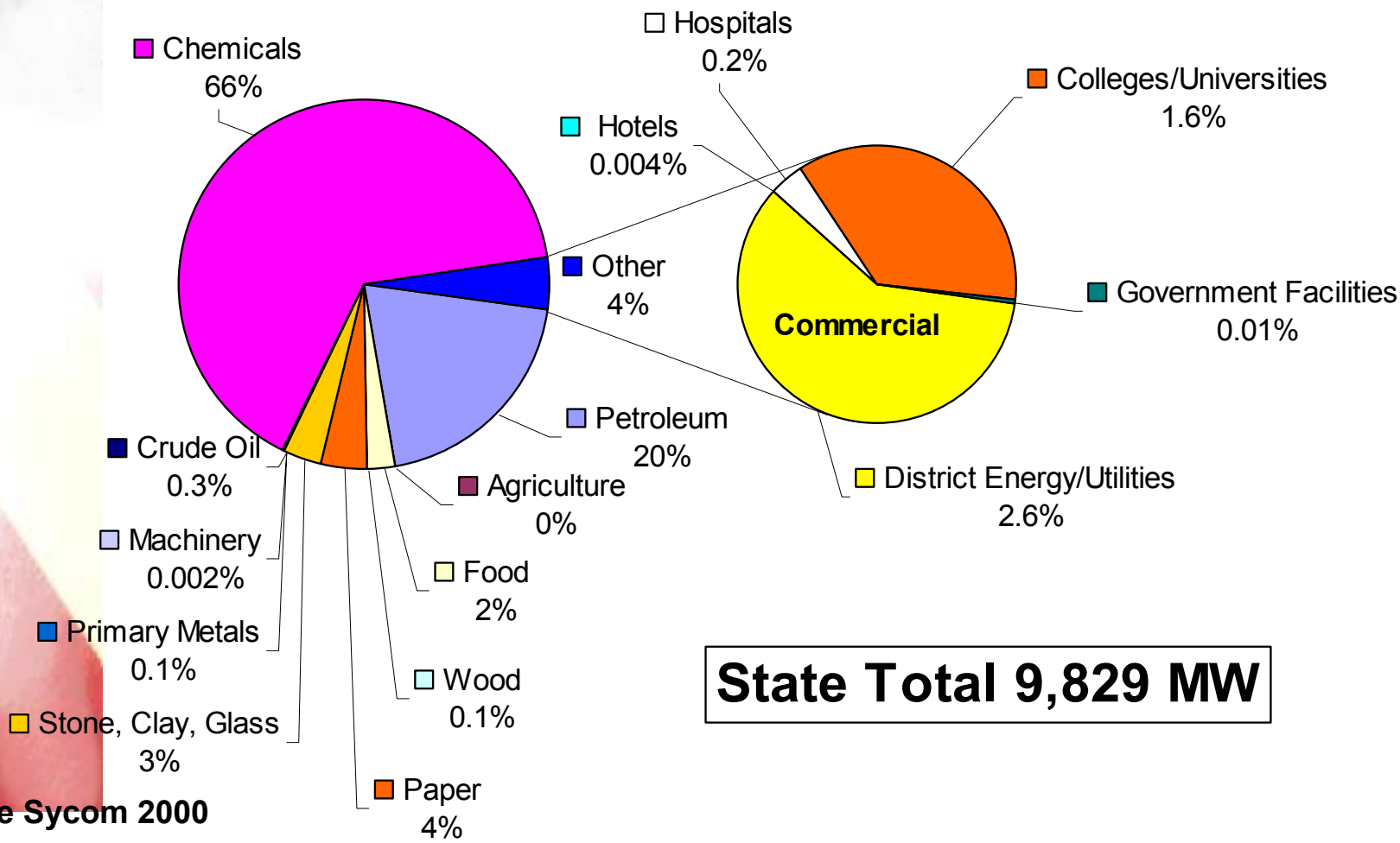
Commercial and Institutional Market Segments

Application	Electric Demand	Thermal Demand
Hotels/Motels	100 kW – 1+ MW	Domestic hot water, space heating, pools
Nursing Homes	100-500 kW	Domestic hot water, space heating, laundry
Hospitals	300 kW – 5+ MW	Domestic hot water, space heating, laundry
Schools	50 – 500 kW	Domestic hot water, space heating, pools
Colleges/Universities	300 kW – 30 MW	Centralized space heating, domestic hot water
Commercial Laundries	100 – 800 kW	Hot water
Car Washes	100 – 500 kW	Hot water
Health Clubs/Spas	50 – 500 kW	Domestic hot water, space heating, pools
Country/Golf Clubs	100 kW – 1 MW	Domestic hot water, space heating, pools
Museums	100 kW – 1+ MW	Space heating, domestic hot water
Correctional Facilities	300 kW – 5 MW	Domestic hot water, space heating
Water Treatment/Sanitary	100 kW – 1 MW	Process heating
Large Office Buildings	100 kW – 1+ MW	Domestic hot water, space heating
Extended Service Restaurants	50 - 300 kW	Domestic hot water, absorption cooling, desiccants
Supermarkets	100 – 500 kW	Desiccants, domestic hot water, space heating
Refrigerated Warehouses	300 kW – 5 MW	Desiccants, domestic hot water
Medium Office Buildings	100 – 500 kW	Absorption cooling, space heating, desiccants

Status of CHP in Texas

- Leads the nation in installed CHP
- National model for CHP regulations
  - TPUC CHP interconnection rule
  - TCEQ small generation permitting - basis for RAP model rule
- Challenges remaining
  - Triple-challenge of electric demand, environment and natural gas constraints
  - Remaining utility tariff issues

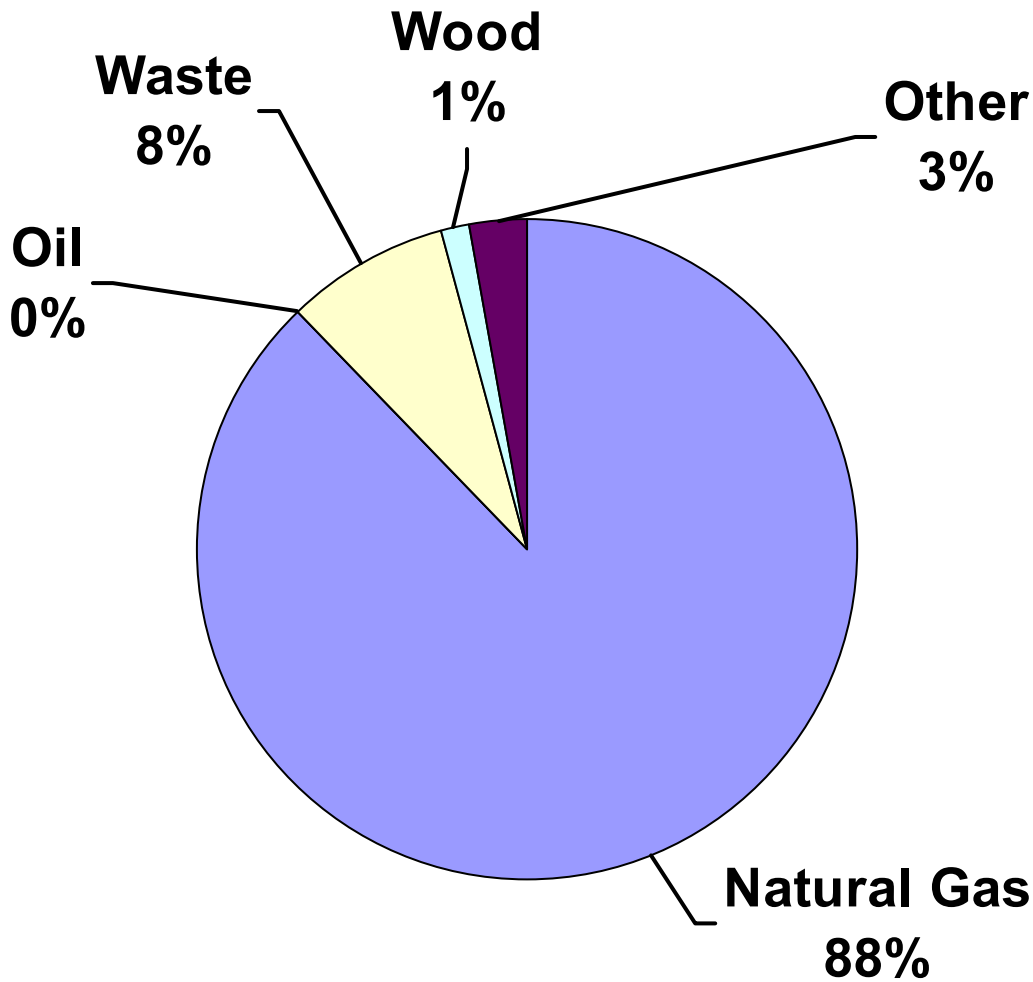
CHP Capacity in Texas by End User Sector



State Total 9,829 MW

Source: Onsite Sycom 2000

CHP Capacity by Fuel Type in Texas

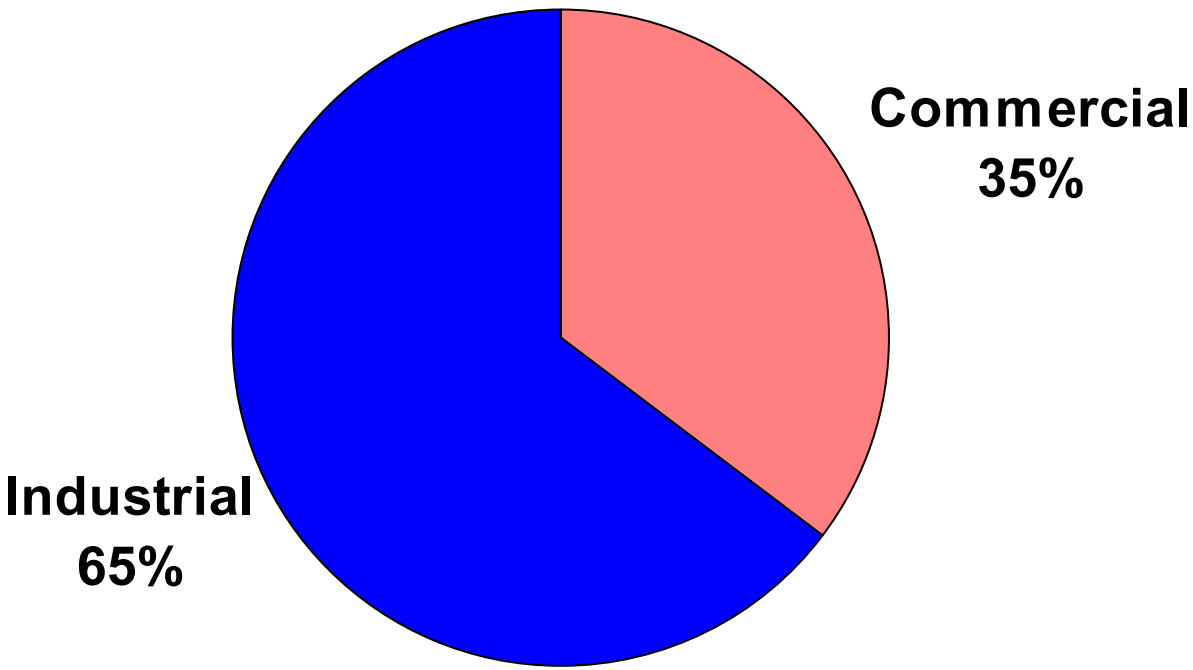


Source: Onsite Sycom 2000

CHP's Role in Texas's Energy Future

- Help address emissions issues
- Help with new, clean generation near demand
- Use gas resources more efficiently
- Reduce cost of meeting energy needs
- Modernize energy infrastructure

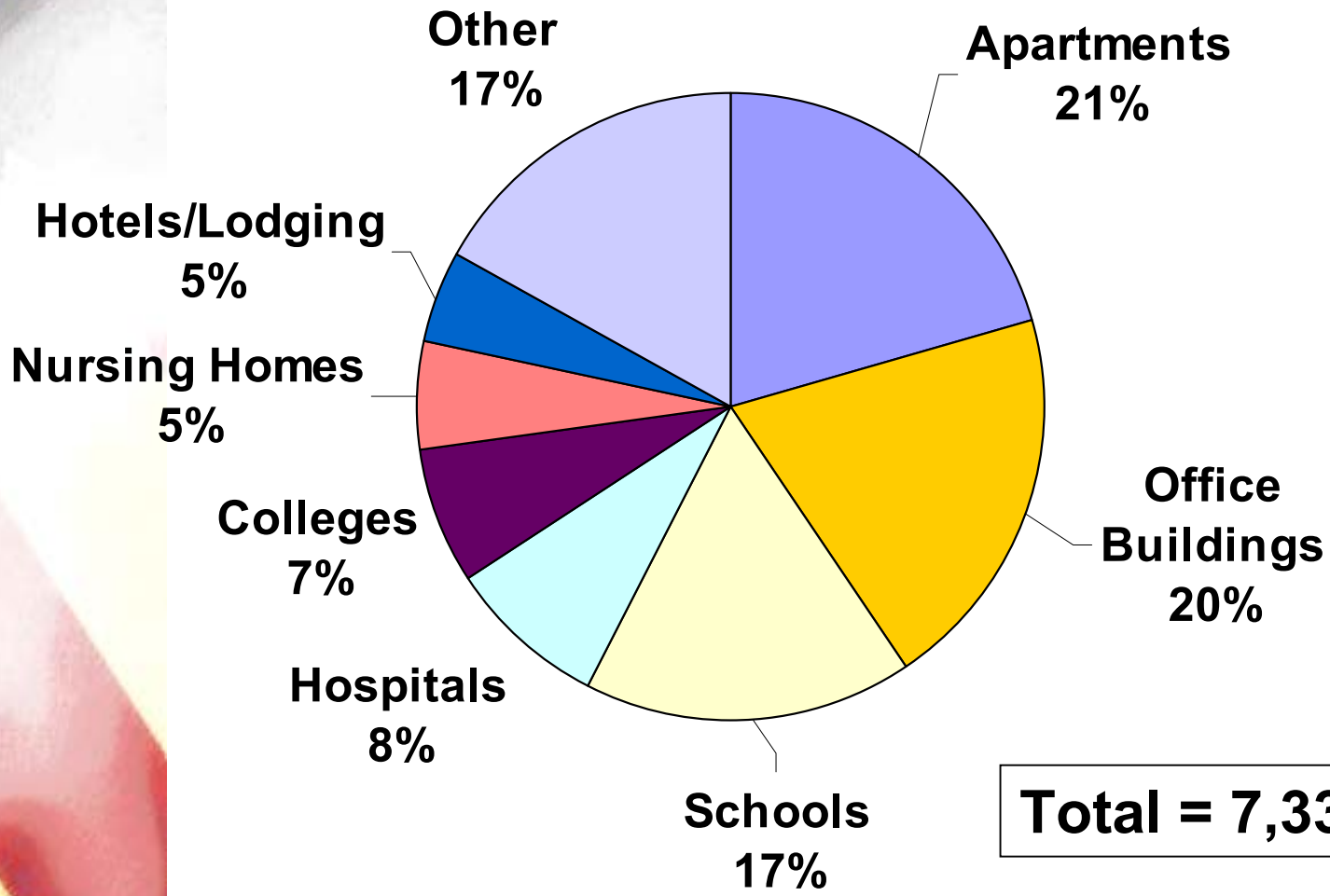
Potential for Additional CHP Capacity In Texas



Total potential = 20,730 MW

Source: Onsite Sycom 2000

Commercial Sector CHP Capacity Potential in Texas



Total = 7,330 MW

Source: Onsite Sycom 2000

Conclusion

- CHP represents an important
  - energy,
  - strategic and
  - environmental resource
- The Technologies are here!
- What is needed is a paradigm shift in the way we think about energy
- Need to overcome market inertia

DOE Solicitation Overview

Research, Development and Demonstration of Packaged Cooling, Heating and Power Systems for Buildings

DOE/ORNL Solicitation

- Research and Development of Packaged / Modular Building Cooling Heating (BCHP) Systems
- Two Phases
  - Product definition & prototype development
  - Product/system development, field benchmarking and commercialization

Phase 1 - Scope of Work

- Subcontract will be cost reimbursable
- Awards to Major Manufacturers, Packagers or Design-Build Companies
- Only Phase 1 Teams Eligible for Subsequent Phases
- Phase 1 Completion - Estimated at 2 Years

Four Key Technical Areas

- Thermally Activated Technologies
  - Absorption cooling
  - Thermal heating
  - Humidity controls
- Onsite Power Technology
- Controls Development
- Systems Integration

Thermally Activated Technologies

"Without viable use for the heat energy rejected from the making of electricity, there would be no benefit from BCHP"

- Potential Uses Include:
  - Cooling, dehumidification, humidification, water heating, steam heating, drying and shaft power from heat energy

BCHP Scope of Work

- Packaged and Modular Systems Development Focuses on Innovative Integration of On-Site/Near-Site Power Generation and Thermally Activated Systems to be Incorporated Into Individual Buildings.

BCHP Scope of Work (continued)

- Packaged or Modular BCHP Systems
  - Commercial Buildings
  - Institutional Buildings
  - Government Facilities
  - District Energy Systems that Distribute Thermal Energy to:
    - College Campuses
    - Hospital Complexes
    - Industrial Parks
    - Large Commercial Campus Developments

Burns & McDonnell
BCHP Team Project Approach

Burns & McDonnell

BCHP Program Manager

- Integrated Design-Build Company
- Founded in 1898
- 100% Employee Owned - 1,700 Employees
- More Than 100 Years Expertise with in Energy Generation Projects
- 20 Regional Offices - Projects Worldwide

Solar Turbines Incorporated

Industrial Turbine Supplier

- Subsidiary of Caterpillar
- Leading U.S. Supplier of Industrial Turbines Ranging from 1 to 13 MW
- Proven Technology with Strong Technical, Research & Development Expertise
- Headquartered in San Diego with a Global Presence

Broad USA, Inc.

Absorption Chiller Supplier

- Worlds Largest Manufacturer of Absorption Chillers
- 1,200 Units Annually = Over 500,000 Tons with More Than 6,000 Units in Operation
- The Only Dedicated Manufacturer of Absorption Chillers with a 3.3 Million ft^2 Manufacturing Facility
- Proven Track Record with the DOE

Purpose

- By **combining existing proven** technologies...
  - Determine if this is better than existing configurations
  - Determine the optimum configuration of the system
  - Develop method to properly size a BCHP system for a specific load profile

BCHP Statement of Work

- Task 1 - **Prepare Project Plan**
- Task 2 - **Packaged Systems Concept Definition**
- Task 3 - Analytical Optimization and Preferred Hardware Description/ Specification
- Task 4 - Testing and Rating Procedures and Standards

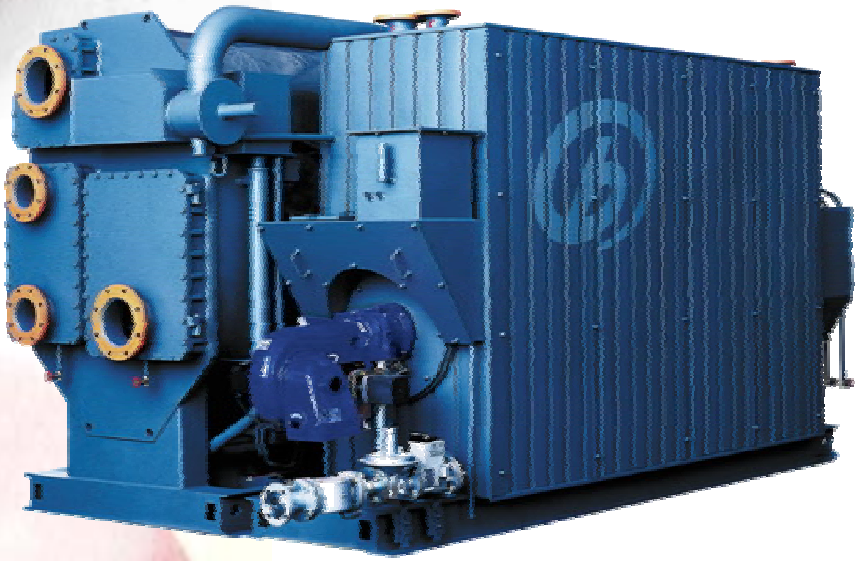
BCHP Statement of Work (continued)

- Task 5 - Prototype Development and Fabrication
- Task 6 - Laboratory Testing of Prototype Packaged BCHP System

Solar Turbines - Centaur 50

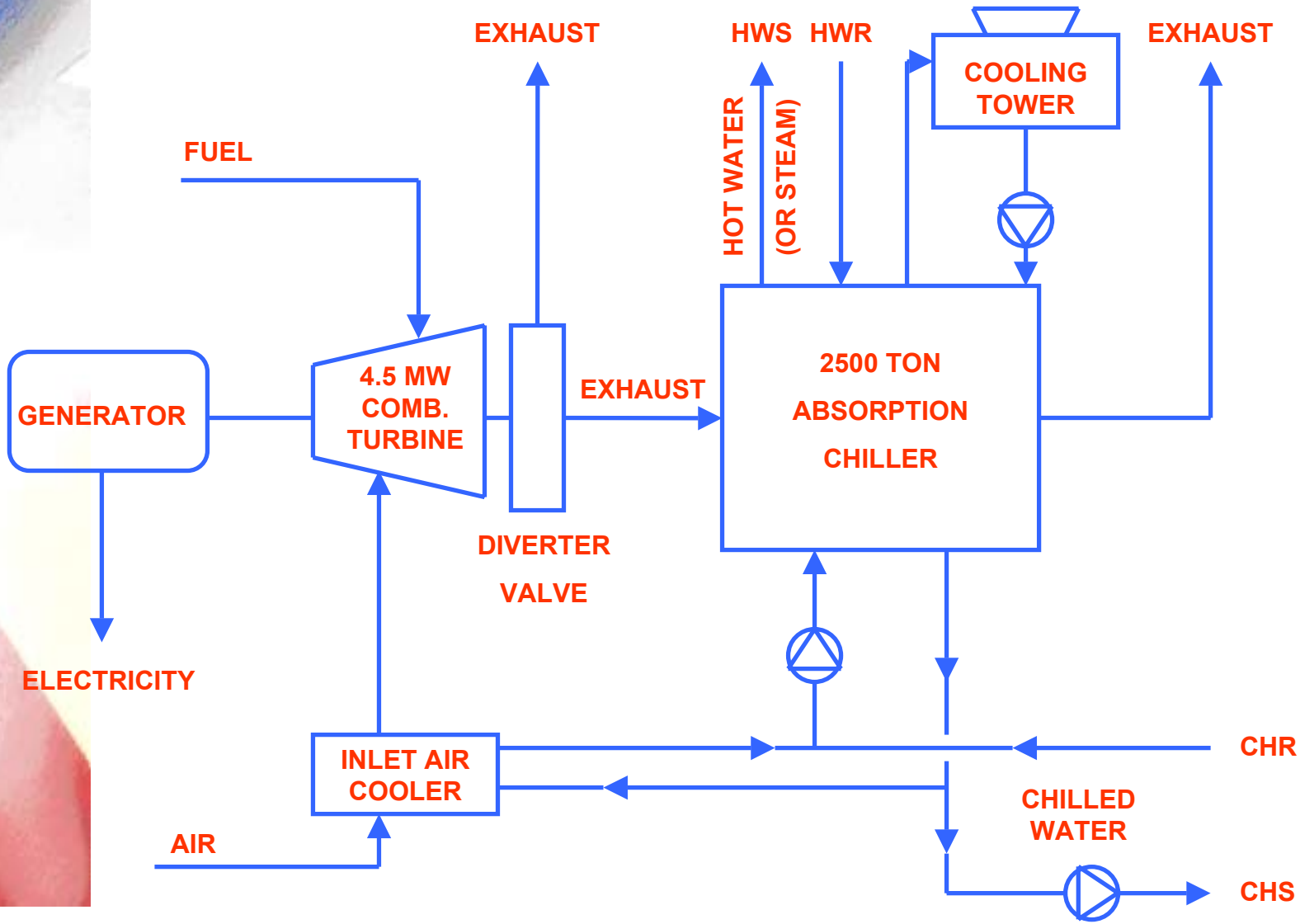
- Nameplate: 4.4 MW
- Exhaust: 950 ºF
- Heat Rate: 11,905 HHV
- Low NOx: 15 ppm

Broad - Spectrum



- Indirect-Fired Absorber
  - Nominal 2500 Tons
    Fuel: Turbine Exhaust

System Concept



Issues

- Emissions
  - Effect of running the turbine exhaust through the high stage generator
- Economics
  - Is this more efficient and cheaper than a HRSG
  - Gas cooling vs. electric cooling
  - Turbine exhaust-fired vs. steam turbine chiller
  - Must run turbine to get free cooling/heating
- Flue gas diversion

Estimated Project Schedule

• Project Plan Completed	02/2002
• Concept/Construction Cost Estimate	02/2003
• Letter of Intent	03/2003
• Finalize Contract	05/2003
• Prefabrication of Modules	09/2003
• Installation & Commissioning	12/2003
• Begin Performance Testing	04/2003
• Final Report & Close-out	12/2004

Current Project Status

- Site selection has been completed and the project will be sited in Austin, TX
- BCHP economic model and preliminary cost estimate has been developed
- BCHP will designed to operate in a base load configuration
- BCHP will have the ability to supply power to the grid

Expanding the BCHP Team

- Other parties interested in collaborating and possibly providing some funding
  - Austin Energy
  - EPRI
  - GTI
  - University of Texas
  - Other Research Entities

Summary
Benefits of BCHP

- Variety of Potential Uses Include:
  - Cooling, dehumidification, humidification, water heating, steam heating, drying and shaft power from heat energy
- Highly reliable on-site power generation
- Uses exhaust without a waste heat boiler providing project cost reduction, decreased O&M costs, improved capacity, and increased efficiency

Summary

Benefits of BCHP

- Greater than 80% (Btu Out/Btu In)
- Approximately 500 Tons of ***"free"*** cooling per MW of generation
- Direct-fired absorber COP of 1.2 raised to 1.6 from supplementing the gas with exhaust
- Low emission gas turbine generator

Questions?

Thank You for your Attention and Interest